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(54) TOUCH SCREEN, TOUCH SENSING DEVICE AND A METHOD OF DRIVING THE SAME

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(51) **Int. Cl.**

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G06F 3/044	(2006.01)
G09G 3/34	(2006.01)
G09G 3/36	(2006.01)

(52) **U.S. Cl.**

CPC ***G06F 3/0412*** (2013.01); ***G06F 3/044*** (2013.01); ***G09G 3/3406*** (2013.01); ***G09G 3/3648*** (2013.01); *G06F 2203/04111* (2013.01); *G06F 2203/04112* (2013.01)

(58) **Field of Classification Search**

CPC G06F 3/044; G06F 3/0412; G06F 3/0416; G02F 1/13338

USPC 345/173, 174

See application file for complete search history.

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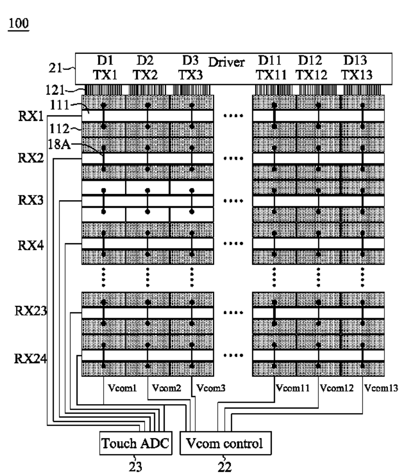
(57) **ABSTRACT**

A touch sensing device includes a first conductive layer that acts as a common voltage layer in a display mode; and a second conductive layer electrically isolated from the first conductive layer, the second conductive layer having source lines that transfer data to be displayed in the display mode and act as transmitting (TX) electrode lines in a touch sensing mode. The first conductive layer includes RX electrode lines and blocks that are disposed among and separated by the RX electrode lines. The RX electrode lines and the blocks are electrically connected to a common voltage in the display mode.

21 Claims, 13 Drawing Sheets



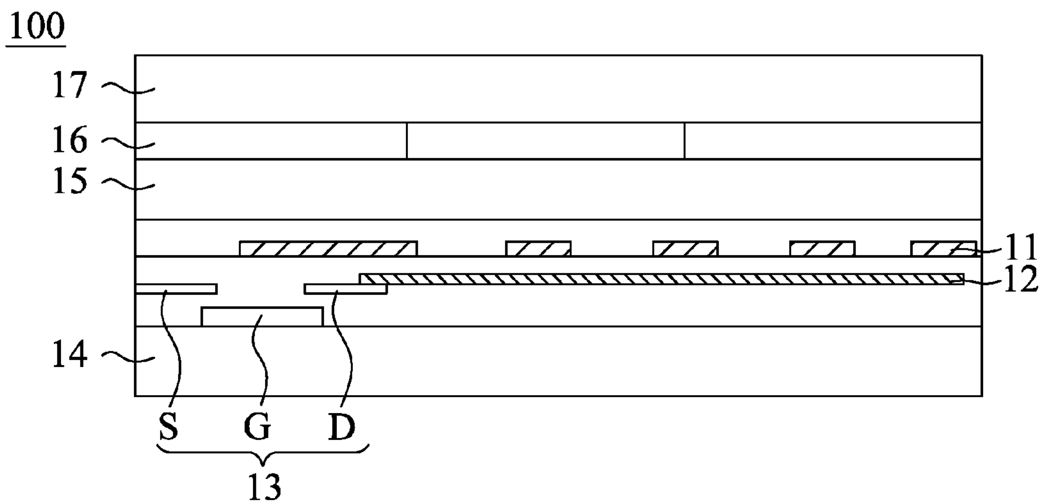


FIG.1A

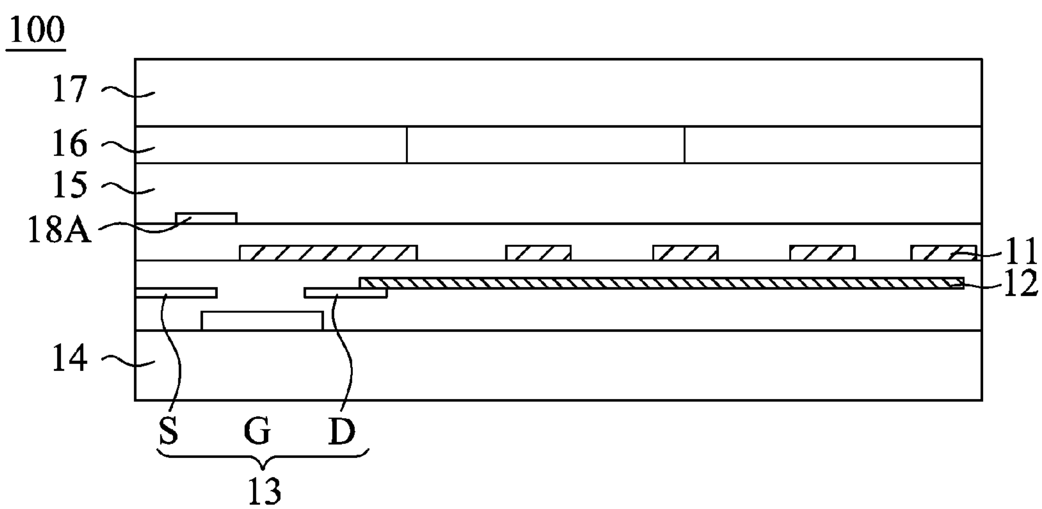


FIG.1B

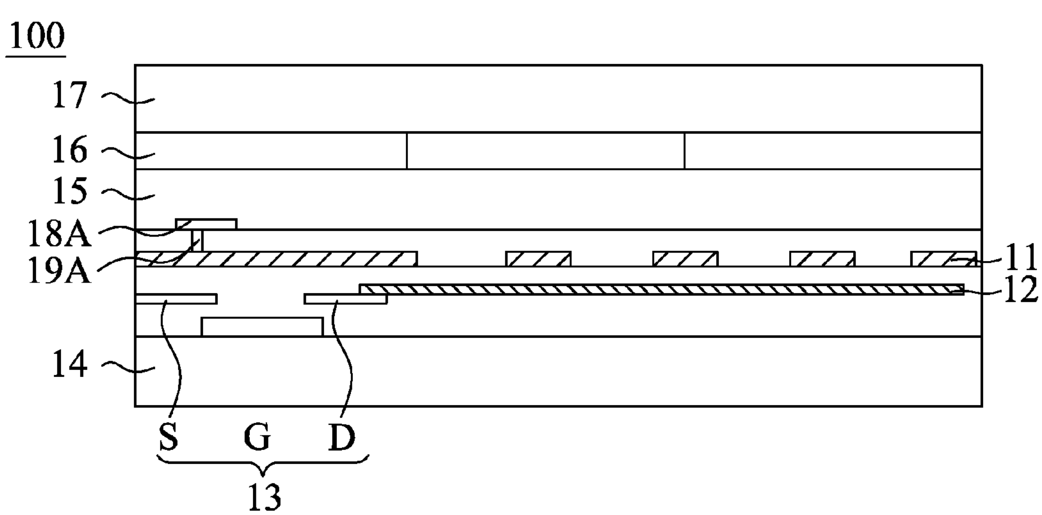


FIG.1C

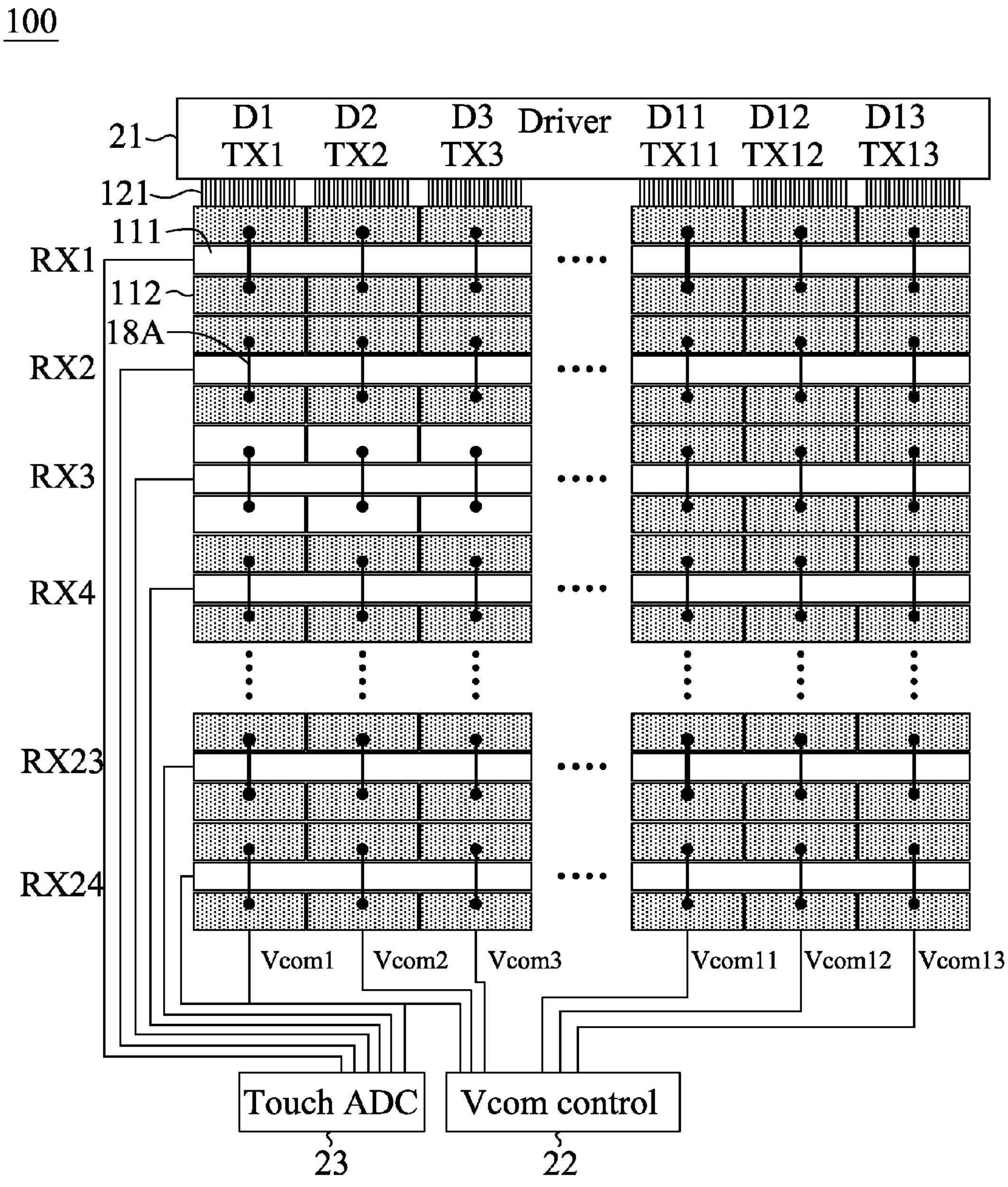

100
21
D1 TX1
D2 TX2
D3 TX3
Driver
D11 TX11
D12 TX12
D13 TX13
121
111
RX1
112
18A
RX2
RX3
RX4
RX23
RX24
Vcom1
Vcom2
Vcom3
Vcom11
Vcom12
Vcom13
Touch ADC
Vcom control
23
22

FIG.2A

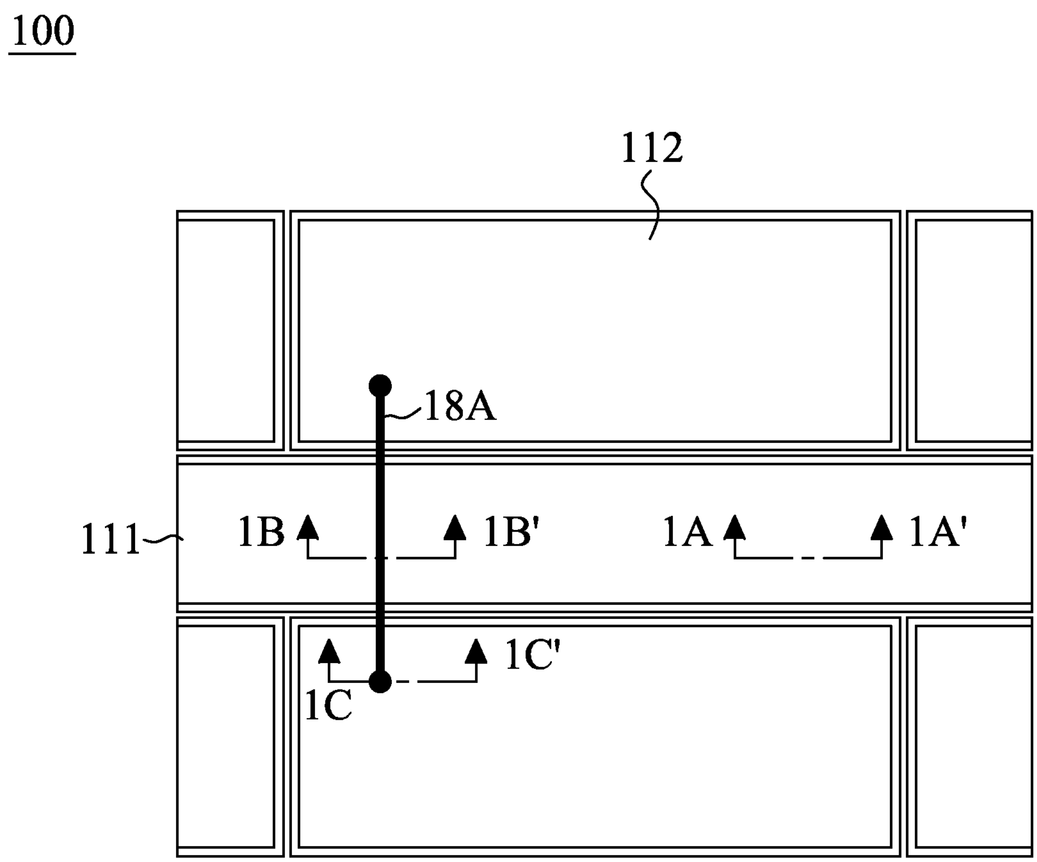


FIG.2B

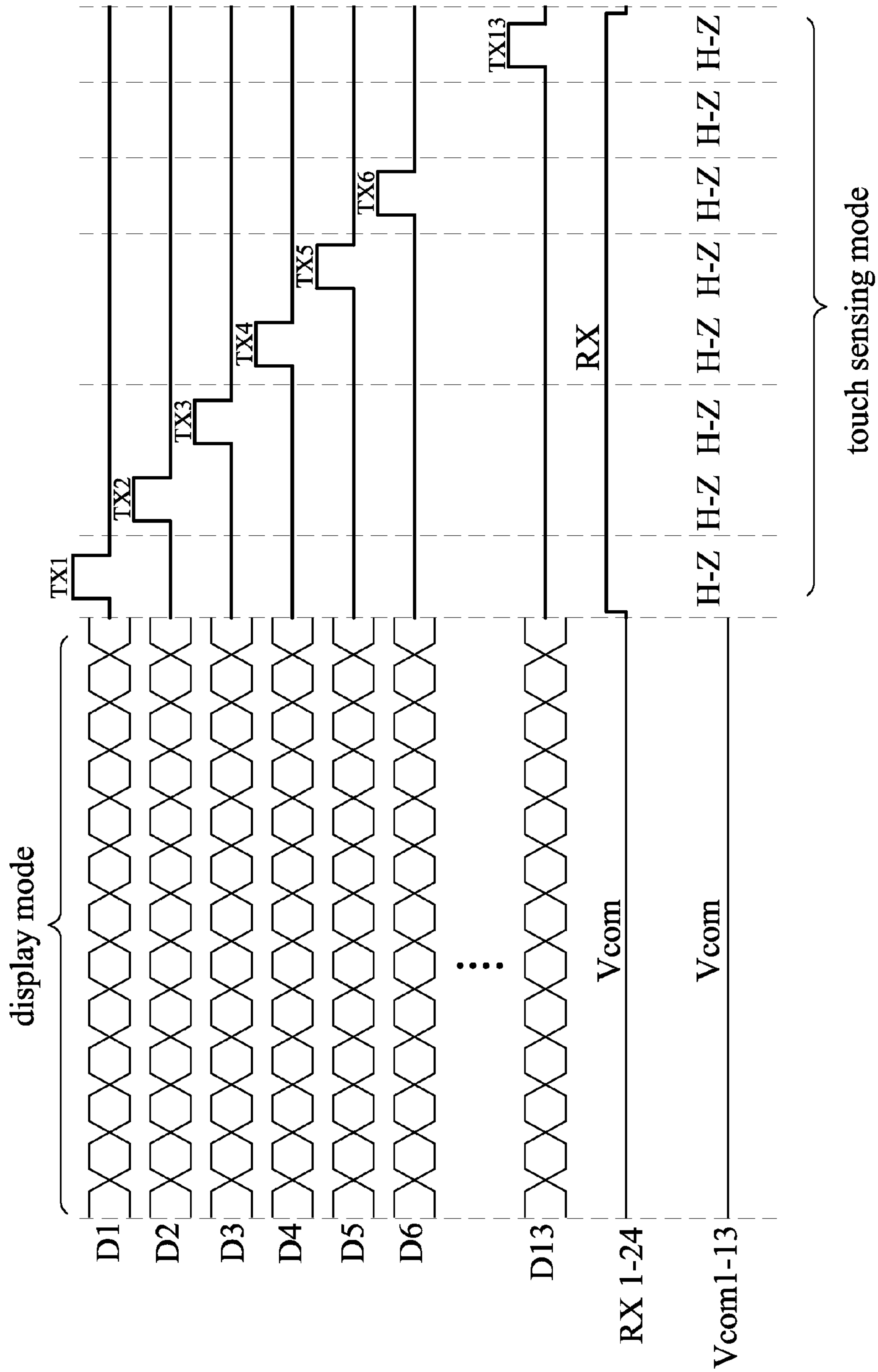

display mode
touch sensing mode
D1
D2
D3
D4
D5
D6
D13
RX 1-24
Vcom1-13
TX1
TX2
TX3
TX4
TX5
TX6
TX13
RX
Vcom
Vcom
H-Z H-Z
H-Z H-Z
H-Z H-Z
H-Z H-Z
H-Z H-Z
H-Z H-Z
H-Z H-Z
H-Z H-Z

FIG.3A

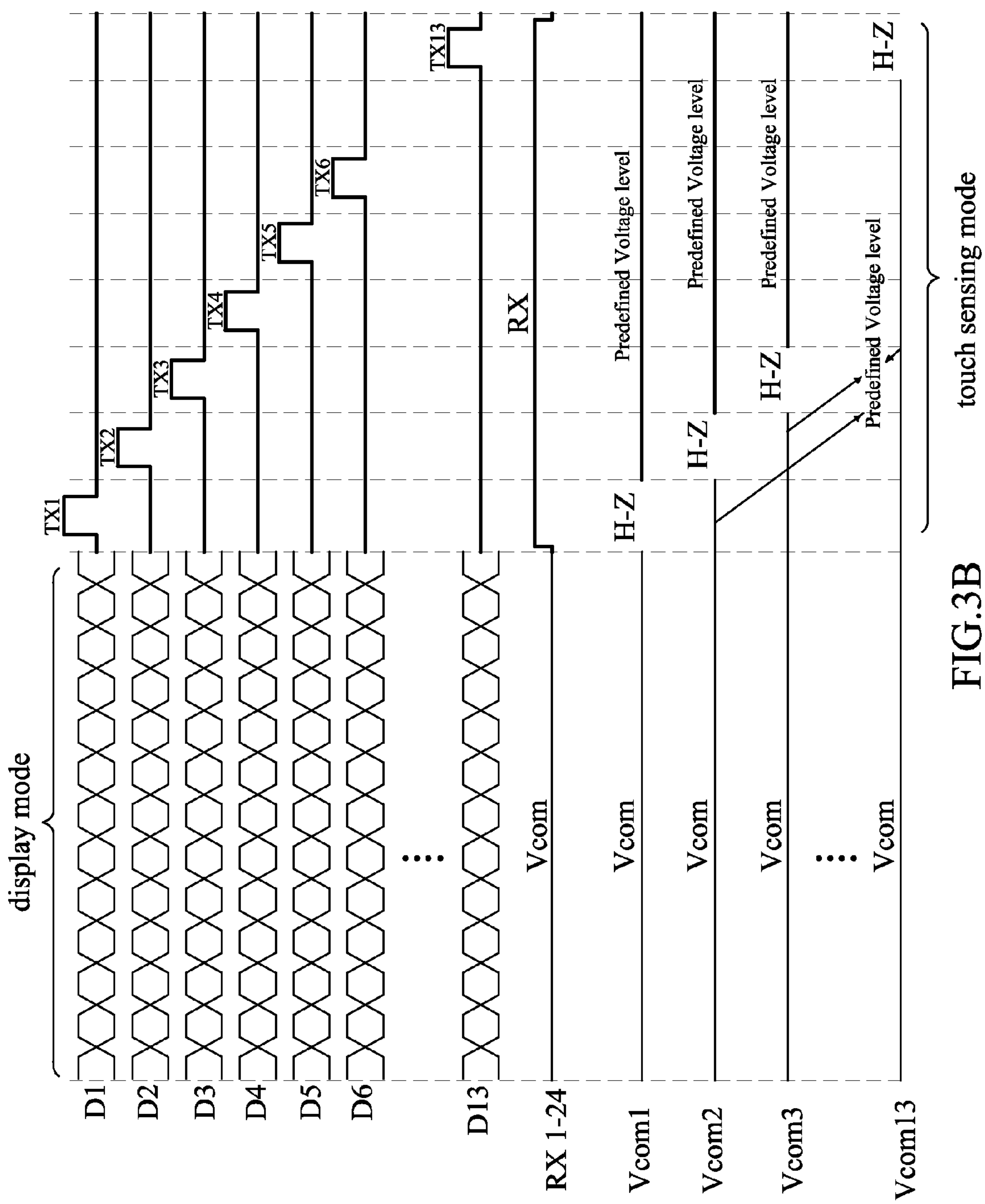

display mode
touch sensing mode
D1
D2
D3
D4
D5
D6
D13
RX 1-24
Vcom1
Vcom2
Vcom3
Vcom13
Vcom
TX1
TX2
TX3
TX4
TX5
TX6
TX13
RX
H-Z
Predefined Voltage level

FIG.3B

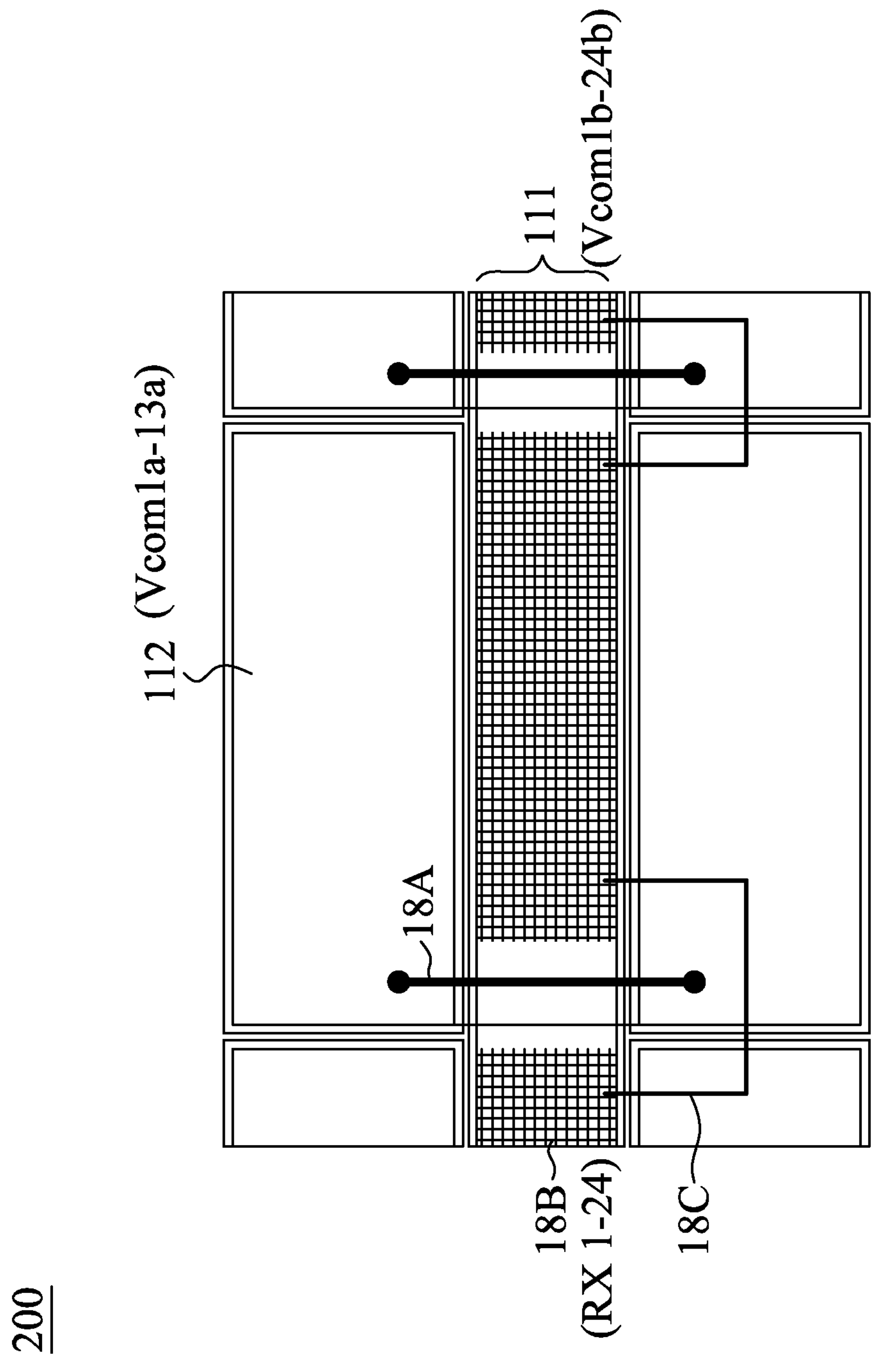


FIG.4

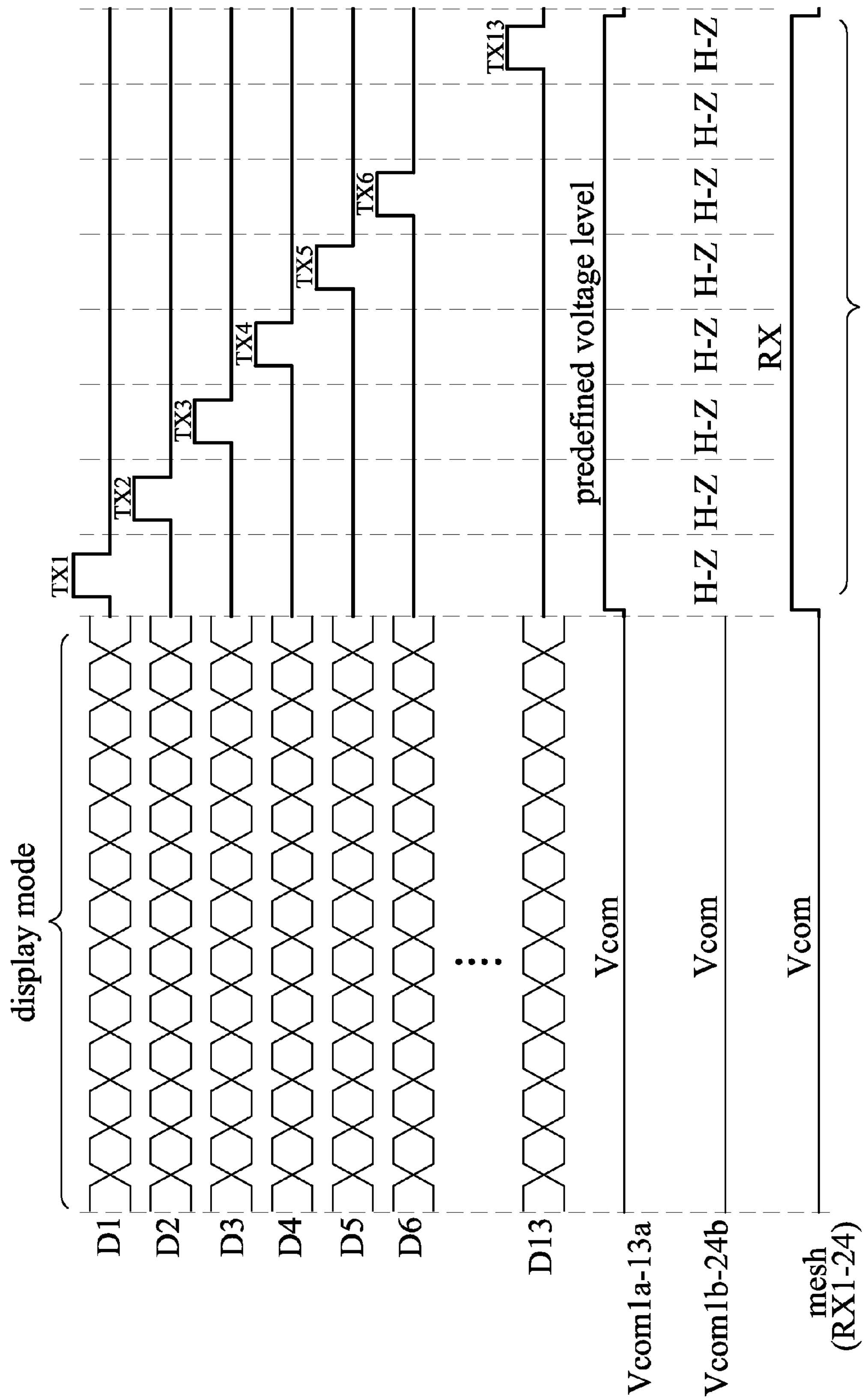
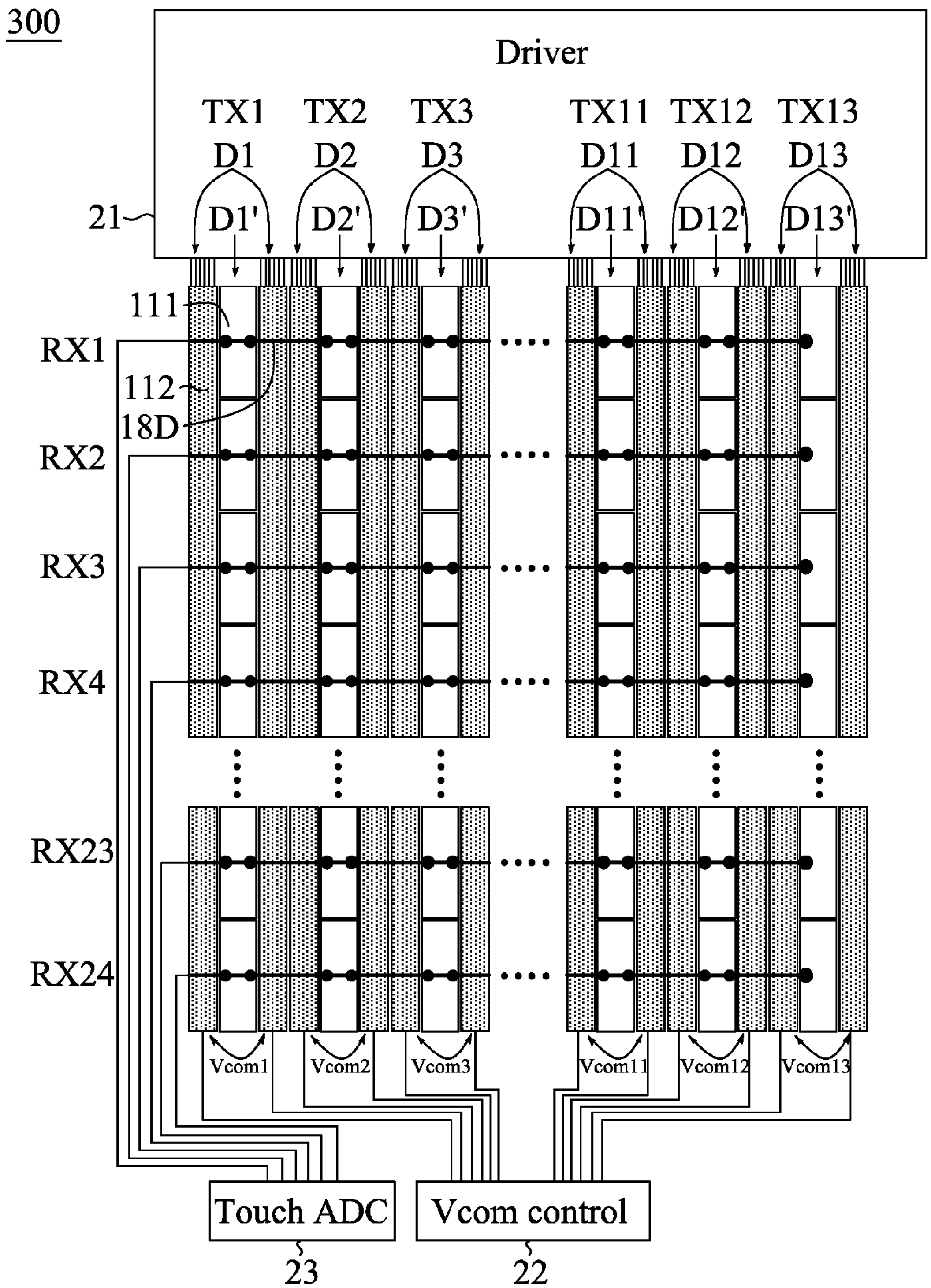

display mode
D1
D2
D3
D4
D5
D6
D13
Vcom1a-13a
Vcom1b-24b
mesh (RX1-24)
Vcom
Vcom
Vcom
TX1
TX2
TX3
TX4
TX5
TX6
TX13
predefined voltage level
H-Z H-Z H-Z H-Z H-Z H-Z H-Z H-Z
RX
touch sensing mode

FIG.5



300
Driver
TX1
TX2
TX3
TX11
TX12
TX13
D1
D2
D3
D11
D12
D13
D1'
D2'
D3'
D11'
D12'
D13'
21
111
112
18D
RX1
RX2
RX3
RX4
RX23
RX24
Vcom1
Vcom2
Vcom3
Vcom11
Vcom12
Vcom13
Touch ADC
Vcom control
23
22

FIG.6A

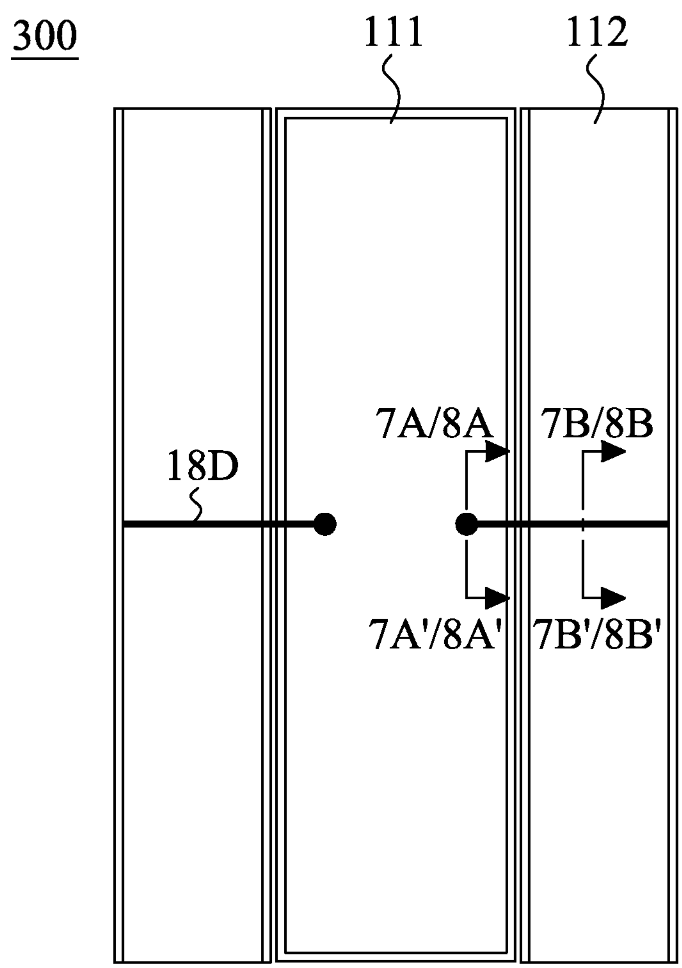


FIG.6B

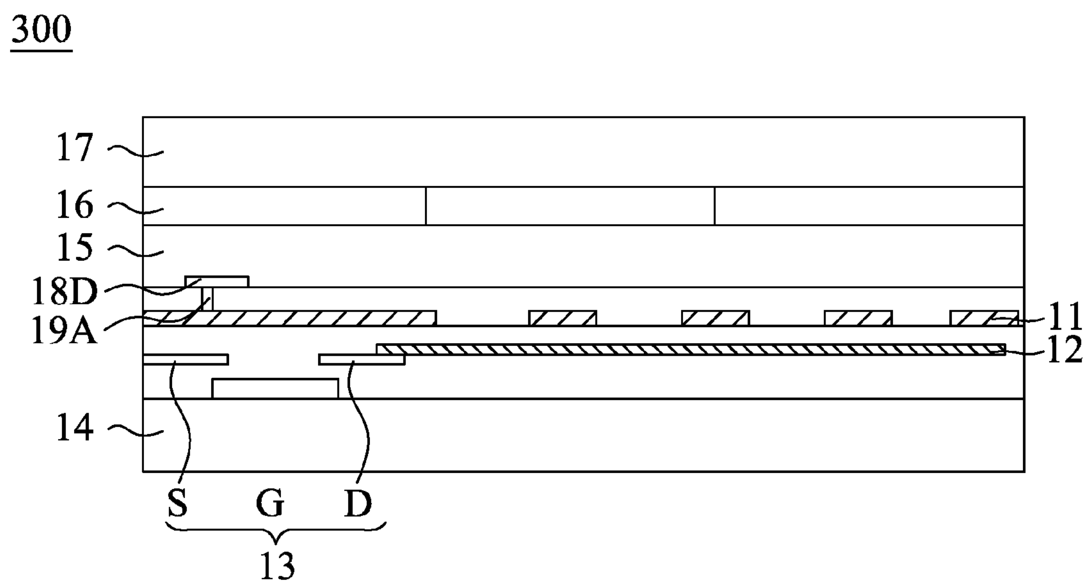


FIG.7A

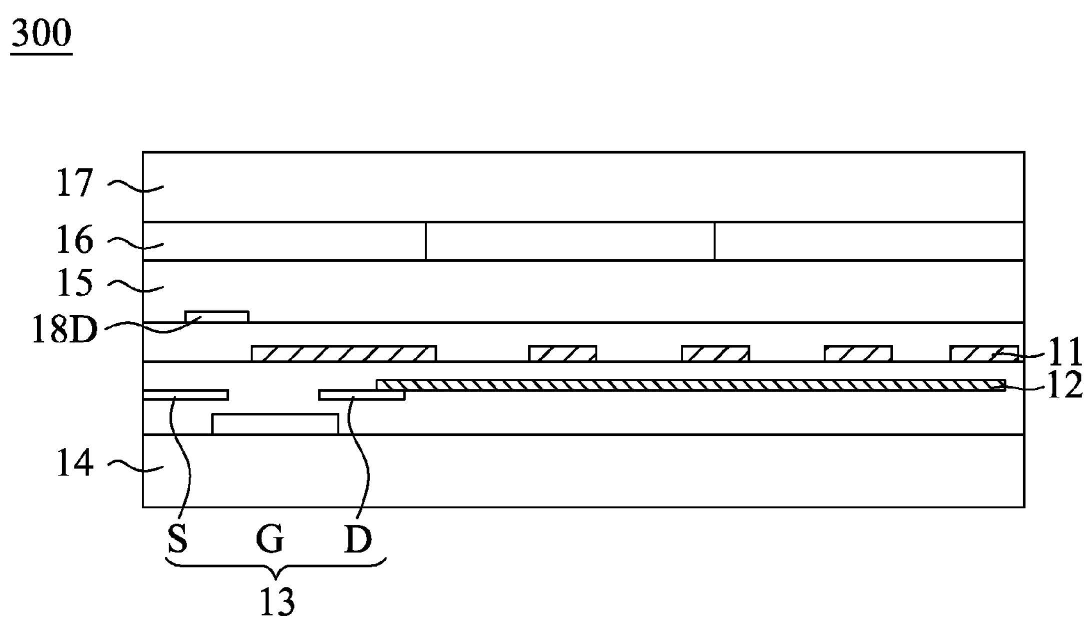


FIG.7B

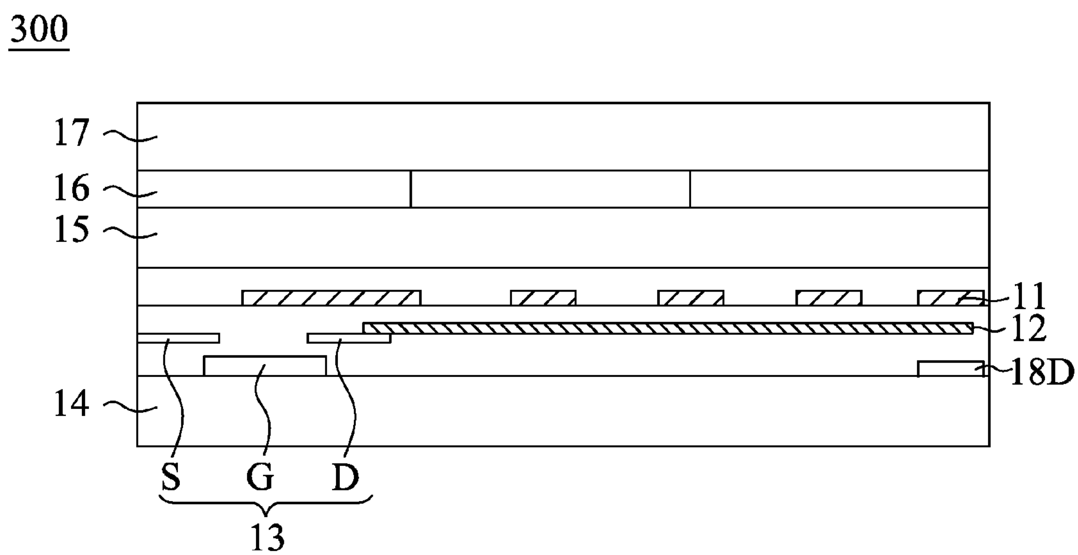


FIG.8A

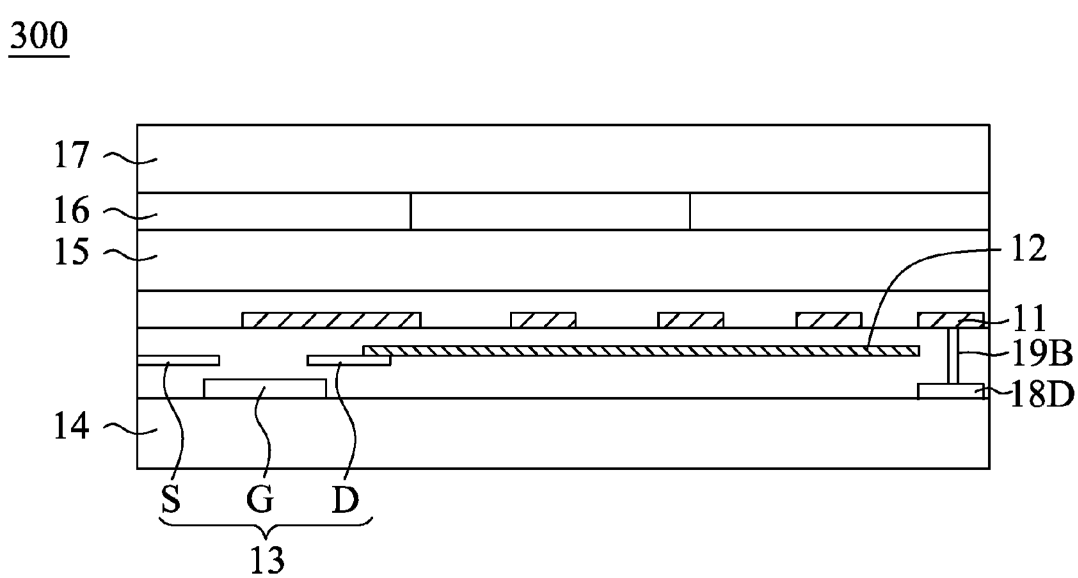


FIG.8B

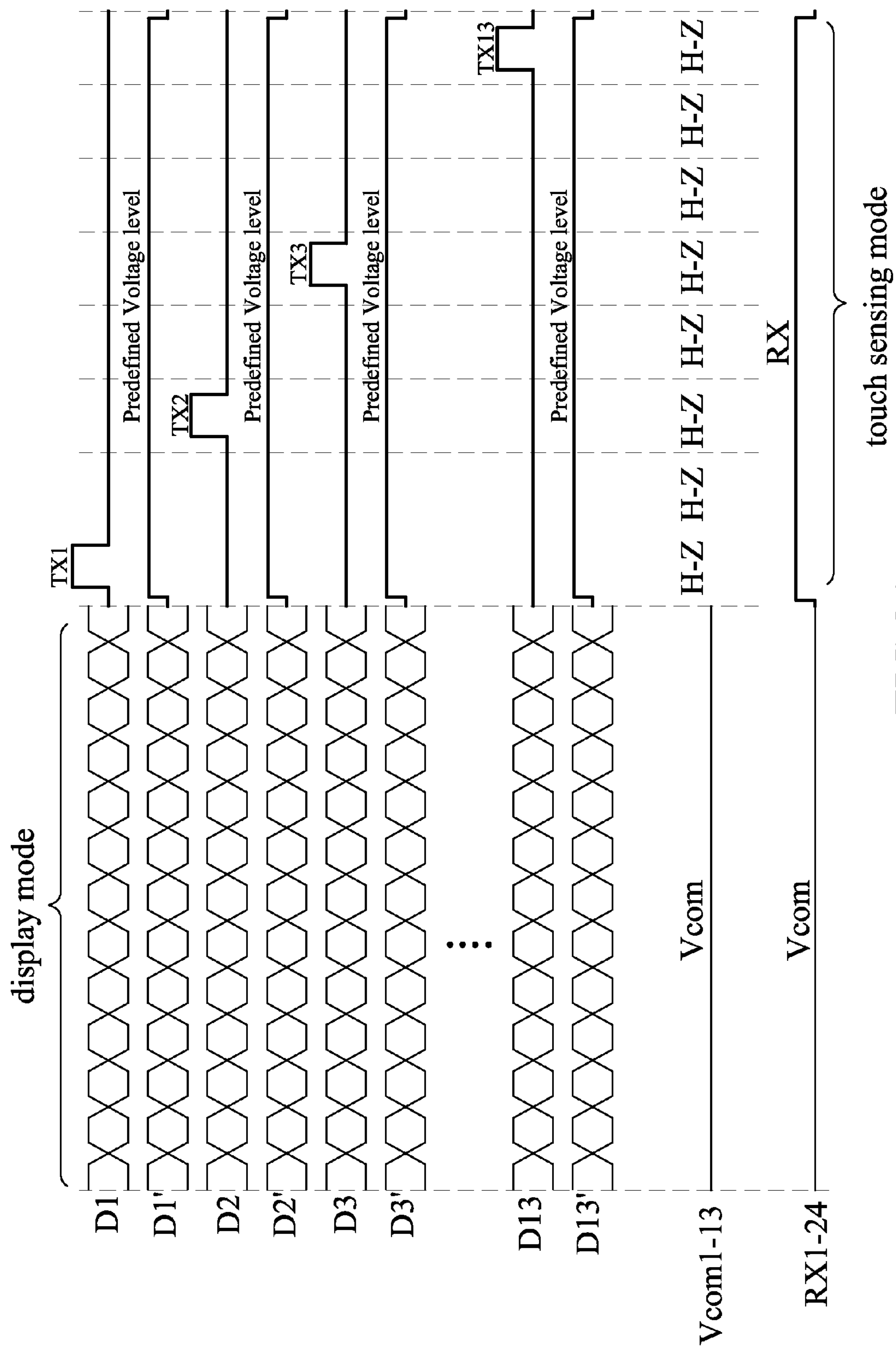

display mode
touch sensing mode
D1
D1'
D2
D2'
D3
D3'
D13
D13'
Vcom1-13
RX1-24
TX1
TX2
TX3
TX13
Predefined Voltage level
Predefined Voltage level
Predefined Voltage level
Predefined Voltage level
Vcom
Vcom
H-Z H-Z H-Z H-Z H-Z H-Z H-Z H-Z
RX

FIG.9A

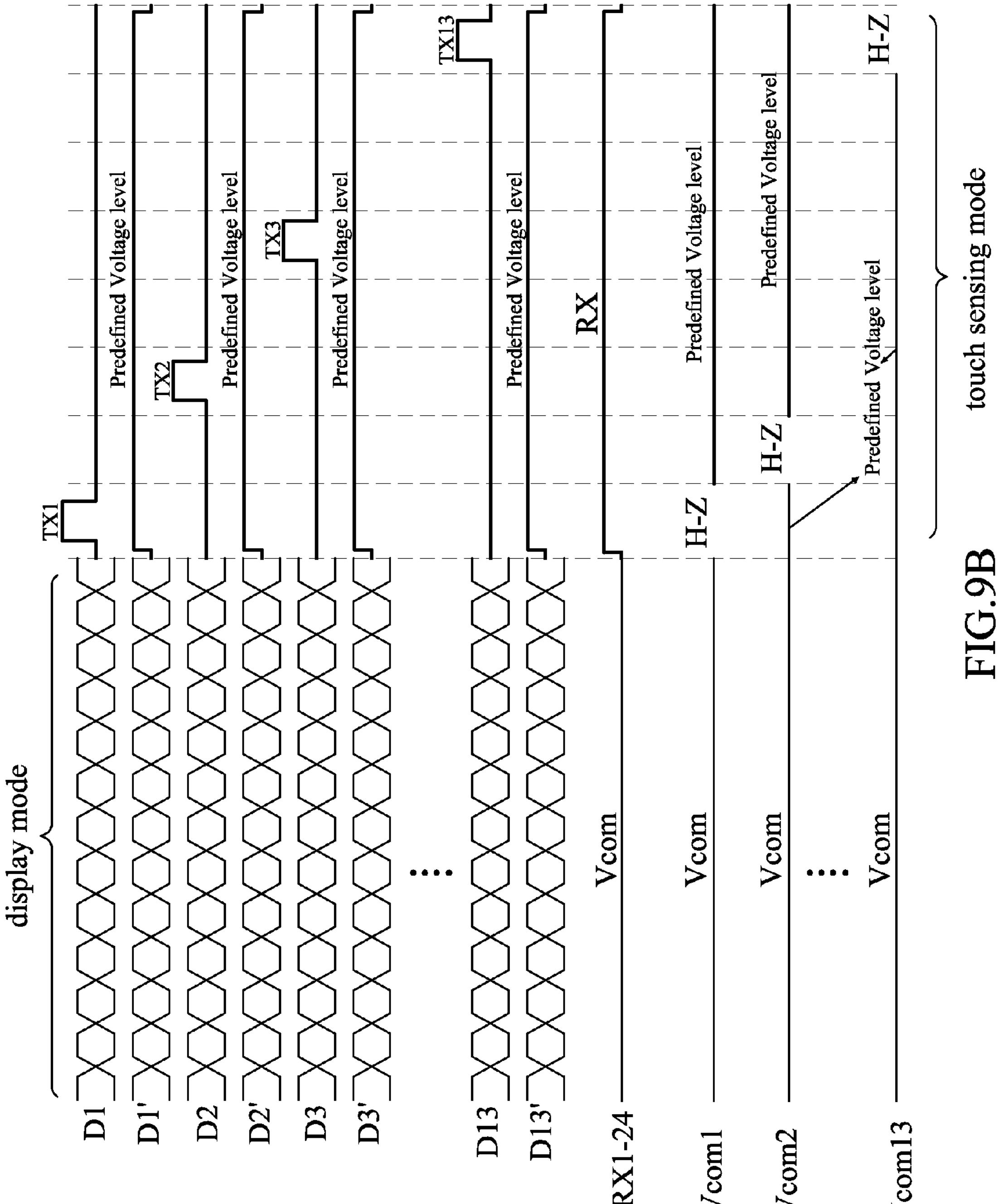

display mode
touch sensing mode
TX1
TX2
TX3
TX13
Predefined Voltage level
RX
H-Z
Vcom
D1
D1'
D2
D2'
D3
D3'
D13
D13'
RX1-24
Vcom1
Vcom2
Vcom13

FIG.9B

TOUCH SCREEN, TOUCH SENSING DEVICE AND A METHOD OF DRIVING THE SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Application No. 62/062,102, filed on Oct. 9, 2014, U.S. Provisional Application No. 62/069,129, filed on Oct. 27, 2014, and U.S. Provisional Application No. 62/072,314, filed on Oct. 29, 2014. The entire contents of the foregoing applications are expressly incorporated by reference herein.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to a touch screen, and more particularly to a liquid crystal display embedded with a touch sensing device.

2. Description of Related Art

A touch screen is an input/output device that combines touch technology and display technology to enable users to directly interact with what is displayed. A capacitor-based touch panel is a commonly used touch panel that utilizes capacitive coupling effect to detect touch position. Specifically, capacitance corresponding to the touch position changes and is thus detected, when a finger touches a surface of the touch panel.

In order to produce thinner touch screens, in-cell technology has been adopted that eliminates one or more layers by building capacitors inside the display. Conventional in-cell touch screens, however, require separate architectures or schemes for driving the display part and the touch part. Accordingly, a need has arisen to propose a novel in-cell architecture and scheme of a touch screen that has a more compact form factor and greater driving efficiency.

SUMMARY OF THE INVENTION

In view of the foregoing, it is an object of the embodiment of the present invention to provide a touch screen embedded with a touch sensing device that has compact form factor and performs in an efficient manner.

According to one embodiment, a touch screen includes a first conductive layer, a second conductive layer, a light control layer and a driver. The first conductive layer acts as a common voltage layer in a display mode. The second conductive layer is electrically isolated from the first conductive layer, and has source lines that transfer data to be displayed in the display mode and that act as transmitting (TX) electrode lines in a touch sensing mode. The light control layer is disposed above the first conductive layer and the second conductive layer. The driver acts as a source driver to provide data to be displayed to the source lines in the display mode, and acts as a TX driver to provide transmitting signals in the touch sensing mode. The first conductive layer includes RX electrode lines and blocks that are disposed among and separated by the RX electrode lines, the RX electrode lines and the blocks being electrically connected to a common voltage in the display mode.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1**A-**1**C show cross-sectional views illustrated of a touch screen according to a first embodiment of the present invention;

FIG. **2**A shows a top view illustrated of the first conductive layer of FIG. **1**;

FIG. **2**B shows a partial enlarged view of FIG. **2**A;

FIG. **3**A and FIG. **3**B show exemplary timing diagrams of driving the touch screen according to the first embodiment of the present invention;

FIG. **4** shows a partial top view illustrated of the first conductive layer of a touch screen according to a second embodiment of the present invention;

FIG. **5** shows an exemplary timing diagram of driving the touch screen according to the second embodiment of the present invention;

FIG. **6**A shows a top view illustrated of the first conductive layer of a touch screen according to a third embodiment of the present invention;

FIG. **6**B shows a partial enlarged view of FIG. **6**A;

FIGS. **7**A-**7**B show cross-sectional views illustrated of the touch screen according to the third embodiment of the present invention;

FIGS. **8**A-**8**B show cross-sectional views illustrated of the touch screen according to an alternative third embodiment of the present invention; and

FIG. **9**A and FIG. **9**B show exemplary timing diagrams of driving the touch screen according to the third embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

FIGS. **1**A-**1**C show cross-sectional views illustrated of a touch screen **100** according to a first embodiment of the present invention. The touch screen **100** of the embodiment is a liquid crystal display (LCD) embedded with a touch sensing device. In the embodiment, the touch screen **100** includes, among others, a first conductive layer **11** that acts as a common voltage (Vcom) layer for the LCD when the touch screen is in a display mode, and acts as a receiving (RX) electrode layer when the touch screen **100** is in a touch sensing mode. FIG. **2**A shows a top view illustrated of the first conductive layer **11** of FIG. **1**, and FIG. **2**B shows a partial enlarged view of FIG. **2**A.

The touch screen **100** further includes a second conductive layer **12** being disposed below and electrically isolated from the first conductive layer **11**. The second conductive layer **12** has source (or data) lines **121** respectively connected to thin-field transistors (TFTs) **13**, each being, for example, comprised of a source (S), a drain (D) and a gate (G). The source lines **121** (e.g., D**1**-**13** in FIG. **2**A) transfer data to be displayed in the display mode, and act as transmitting (TX) electrode lines (e.g., TX**1**-TX**13** in FIG. **2**A) in the touch sensing mode.

As shown in FIG. **1**A, the touch screen **100** may include a TFT substrate **14**, on which the TFTs **13** are formed. A light control layer, such as a liquid crystal (LC) layer **15**, is disposed above the first conductive layer **11**. Above the LC layer **15** are color filters (CFs) **16** that are formed on a bottom surface of a CF substrate **17**.

Although the second conductive layer **12** is disposed below the first conductive layer **11** in the present and following embodiments, it is appreciated that the reverse may be adopted in other embodiments.

As shown in FIG. **2**A, the touch screen **100** includes a driver **21** that acts as a source driver to provide data to be displayed in the display mode, and acts as a transmitting (TX) driver to provide transmitting signals in the touch sensing mode. According to one aspect of the embodiment, the first conductive layer **11** includes a plurality of RX electrode lines (e.g., elongated stripes) **111** that are disposed substantially perpendicular to the source lines **121**. The first conductive layer **11** also includes a plurality of blocks **112** that are disposed among the RX electrode lines **111**. The blocks **112** separated by the RX electrode line **111** are electrically connected by a (first) conductive bridge **18**A, as detailed in FIG. **1**B and FIG. **2**B, disposed over the first conductive layer **11**. As exemplified in FIG. **2**A, the blocks **112** connected by the (first) conductive bridges **18**A form Vcom**1**-Vcom**13** column by column, respectively. The conductive bridge **18**A is electrically connected to the first conductive layer **11** through a via **19**A as detailed in FIG. **1**C. In the display mode, all the RX electrode lines **111** and the blocks **112** are electrically connected to a common voltage (Vcom), for example, by a touch analog-to-digital converter (ADC) **23** and under control of a common voltage (Vcom) control unit **22**. In the touch sensing mode, the blocks **112** are floating and the RX electrode lines **111** (e.g., RX**1**-RX**24** in FIG. **2**A) receive touch sensed signals, which are then processed, for example, by the touch ADC **23**.

FIG. **3**A shows an exemplary timing diagram of driving the touch screen **100** according to the first embodiment of the present invention. In the display mode, the driver **21** provides data (e.g., D**0**-D**13**) via the source lines **121**, and the Vcom control unit **22** connects all the RX electrode lines **111** and the blocks **112** to a common voltage (Vcom). Subsequently, in the touch sensing mode, the driver **21** provides transmitting signals (e.g., TX**1**-TX**13**) in turn, and the touch ADC **23**, for example, processes touch sensed signals RX received from the RX electrode lines **111**. The blocks **112** are floating (i.e., in high impedance or H-z) under control of the Vcom control unit **22**. FIG. **3**B shows an alternative timing diagram of driving the touch screen **100** according to the first embodiment of the present invention. In the touch sensing mode, the block **112** associated with an active transmitting signal is floating, and other blocks **112** are maintained at a predefined voltage.

FIG. **4** shows a partial top view illustrated of the first conductive layer **11** of a touch screen **200** according to a second embodiment of the present invention. The present embodiment is similar to the first embodiment with the exceptions that will be described in the following. As shown in FIG. **4**, in addition to the conductive bridges **18**A, conductive meshes **18**B are disposed above the RX electrode line **111** but not connected with the conductive bridges **18**A. In the embodiment, the conductive meshes **18**B are formed on the same layer as the conductive bridges **18**A. Neighboring conductive meshes **18**B are electrically connected by a conductive link **18**C. Moreover, a plurality of dummy meshes (not shown) may be respectively disposed above the blocks **112**, and be electrically isolated from the conductive meshes **18**B and the conductive links **18**C.

FIG. **5** shows an exemplary timing diagram of driving the touch screen **200** according to the second embodiment of the present invention. In the display mode, the driver **21** provides data (e.g., D**0**-D**13**) via the source lines **121**, and the Vcom control unit **22** connects all the RX electrode lines **111**, the blocks **112** and the conductive meshes **18**B to a common voltage (Vcom). Subsequently, in the touch sensing mode, the driver **21** provides transmitting signals (e.g., TX**1**-TX**13**) in turn, and the touch ADC **23**, for example, processes touch sensed signals RX received from the conductive meshes **18**B. The RX electrode lines **111** (e.g., Vcom**1***a*-**13***a*) are maintained at a predefined voltage (e.g., provided by the touch ADC **23**) or at ground or in high impedance, and the blocks **112** (e.g., Vcom**1***b*-**24***b*) are floating (i.e., in high impedance or H-z) under control of the Vcom control unit **22**.

FIG. **6**A shows a top view illustrated of the first conductive layer **11** of a touch screen **300** according to a third embodiment of the present invention, and FIG. **6**B shows a partial enlarged view of FIG. **6**A. Instead of an elongated strip, the RX electrode line **111** of the embodiment includes a plurality of segments that are electrically connected by a (second) conductive bridge **18**D. In one embodiment, the conductive bridge **18**D is electrically connected to the first conductive layer **11** through a via **19**A as detailed in FIG. **7**A, and the conductive bridge **18**D is disposed over the first conductive layer **11** as detailed in FIG. **7**B. In an alternative embodiment, the conductive bridge **18**D is disposed below the second conductive layer **12** as detailed in FIG. **8**A, and the conductive bridge **18**D is electrically connected to the first conductive layer **11** through a via **19**B as detailed in FIG. **8**B.

FIG. **9**A shows an exemplary timing diagram of driving the touch screen **300** according to the third embodiment of the present invention. In the display mode, the driver **21** provides data via the source lines **121** below the blocks **112** (denoted as D**1**-D**13**) and below the RX electrode lines **111** (denoted as D**1**'-D**13**'), and the Vcom control unit **22** connects all the RX electrode lines **111** and the blocks **112** to a common voltage (Vcom). Subsequently, in the touch sensing mode, the driver **21** provides transmitting signals (e.g., TX**1**-TX**13**) in turn to the source lines **121** (e.g., D**1**-D**13**) below the blocks **112** while maintaining a predefined voltage or ground or high impedance at the source lines **121** (e.g., D**1**'-D**13**') below the RX electrode lines **111**, and the touch ADC **23**, for example, processes touch sensed signals RX received from the RX electrode lines **111**. The blocks **112** (e.g., RX**1**-**24**) are floating (i.e., in high impedance or H-z) under control of the Vcom control unit **22**. FIG. **9**B shows an alternative timing diagram of driving the touch screen **300** according to the third embodiment of the present invention. In the touch sensing mode, the block **112** associated with an active transmitting signal is floating, and other blocks **112** are maintained at a predefined voltage.

Although specific embodiments have been illustrated and described, it will be appreciated by those skilled in the art that various modifications may be made without departing from the scope of the present invention, which is intended to be limited solely by the appended claims.

What is claimed is:

1. A touch screen, comprising:

a first conductive layer that acts as a common voltage layer in a display mode;

a second conductive layer electrically isolated from the first conductive layer, the second conductive layer having source lines that transfer data to be displayed in the display mode and act as transmitting (TX) electrode lines in a touch sensing mode;

a light control layer disposed above the first conductive layer and the second conductive layer;

a driver that acts as a source driver to provide data to be displayed to the source lines in the display mode, and acts as a TX driver to provide transmitting signals in the touch sensing mode;

wherein the first conductive layer includes a plurality of RX electrode lines and a plurality of blocks that are disposed among and separated by the plurality of RX electrode lines, the plurality of RX electrode lines and the plurality of blocks being electrically connected to a common voltage in the display mode; and a plurality of first conductive bridges being disposed over the first conductive layer and connecting the plurality of blocks.

2. The touch screen of claim 1, further comprising:

a plurality of thin-field transistors (TFTs) connected to the source lines respectively; and

a TFT substrate, on which the TFTs are disposed.

3. The touch screen of claim 1, wherein the light control layer comprises a liquid crystal layer.

4. The touch screen of claim 1, wherein each said RX electrode line comprises a single elongated stripe along a direction perpendicular to the source lines.

5. The touch screen of claim 1, wherein at least one of the plurality of blocks is floating and the plurality of RX electrode lines receive touch sensed signals in the touch sensing mode.

6. The touch screen of claim 1, further comprising:

a plurality of conductive meshes disposed above the plurality of RX electrode lines but not connected with the plurality of first conductive bridges; and

a plurality of conductive links that connect the plurality of conductive meshes.

7. The touch screen of claim 6, further comprising a plurality of dummy meshes disposed above the plurality of blocks, and electrically isolated from the plurality of conductive meshes and the plurality of conductive links.

8. The touch screen of claim 6, wherein each said RX electrode line comprises a single elongated stripe along a direction perpendicular to the source lines.

9. The touch screen of claim 6, wherein at least one of the plurality of blocks is floating; the plurality of RX electrode lines are maintained at a predefined voltage, at ground or are floating; and the plurality of conductive meshes receive touch sensed signals in the touch sensing mode.

10. A touch screen, comprising:

a first conductive layer that acts as a common voltage layer in a display mode;

a second conductive layer electrically isolated from the first conductive layer, the second conductive layer having source lines that transfer data to be displayed in the display mode and act as transmitting (TX) electrode lines in a touch sensing mode;

a light control layer disposed above the first conductive layer and the second conductive layer;

a driver that acts as a source driver to provide data to be displayed to the source lines in the display mode, and acts as a TX driver to provide transmitting signals in the touch sensing mode;

wherein the first conductive layer includes a plurality of RX electrode lines and a plurality of blocks that are disposed among and separated by the plurality of RX electrode lines, the plurality of RX electrode lines and the plurality of blocks being electrically connected to a common voltage in the display mode;

wherein each said RX electrode line comprises a plurality of segments along a direction perpendicular to the source lines; and

a plurality of second conductive bridges that electrically connect each said RX electrode line.

11. The touch screen of claim 10, wherein at least one of the plurality of blocks is floating; the source lines below the plurality of RX electrode lines are maintained at a predefined voltage, at ground or are floating; and the plurality of RX electrode lines receive touch sensed signals in the touch sensing mode.

12. A touch sensing device, comprising:

a first conductive layer that acts as a common voltage layer in a display mode;

a second conductive layer electrically isolated from the first conductive layer, the second conductive layer having source lines that transfer data to be displayed in the display mode and act as transmitting (TX) electrode lines in a touch sensing mode;

wherein the first conductive layer includes a plurality of RX electrode lines and a plurality of blocks that are disposed among and separated by the plurality of RX electrode lines, the plurality of RX electrode lines and the plurality of blocks being electrically connected to a common voltage in the display mode; and

a plurality of first conductive bridges being disposed over the first conductive layer and connecting the plurality of blocks.

13. The touch sensing device of claim 12, wherein each said RX electrode line comprises a single elongated stripe along a direction perpendicular to the source lines.

14. The touch sensing device of claim 12, wherein at least one of the plurality of blocks is floating and the plurality of RX electrode lines receive touch sensed signals in the touch sensing mode.

15. The touch sensing device of claim 12, further comprising:

a plurality of conductive meshes disposed above the plurality of RX electrode lines but not connected with the plurality of first conductive bridges; and

a plurality of conductive links that connect the plurality of conductive meshes.

16. The touch sensing device of claim 15, further comprising a plurality of dummy meshes disposed above the plurality of blocks, and electrically isolated from the plurality of conductive meshes and the plurality of conductive links.

17. The touch sensing of claim 15, wherein each said RX electrode line comprises a single elongated stripe along a direction perpendicular to the source lines.

18. The touch sensing device of claim 15, wherein at least one of the plurality of blocks is floating; the plurality of RX electrode lines are maintained at a predefined voltage, at ground or are floating; and the plurality of conductive meshes receive touch sensed signals in the touch sensing mode.

19. A touch sensing device, comprising:

a first conductive layer that acts as a common voltage layer in a display mode;

a second conductive layer electrically isolated from the first conductive layer, the second conductive layer having source lines that transfer data to be displayed in the display mode and act as transmitting (TX) electrode lines in a touch sensing mode;

wherein the first conductive layer includes a plurality of RX electrode lines and a plurality of blocks that are disposed among and separated by the plurality of RX electrode lines, the plurality of RX electrode lines and the plurality of blocks being electrically connected to a common voltage in the display mode, each said RX electrode line comprising a plurality of segments along a direction perpendicular to the source lines; and

a plurality of second conductive bridges that electrically connect each said RX electrode line.

20. The touch sensing device of claim 19, wherein at least one of the plurality of blocks is floating; the source lines below the plurality of RX electrode lines are maintained at

a predefined voltage, at ground or are floating; and the plurality of RX electrode lines receive touch sensed signals in the touch sensing mode.

21. A method of driving a touch sensing device, which including a first conductive layer and a second conductive layer having source lines, the first conductive layer including a plurality of RX electrode lines and a plurality of blocks, the method comprising:

electrically connecting the plurality of RX electrode lines and the plurality of blocks to a common voltage in a display mode;

transferring data to be displayed through the source lines in the display mode;

floating at least one of the plurality of blocks in a touch sensing mode;

maintaining the plurality of RX electrode lines at a predefined voltage, at ground or floating in the touch sensing mode; and

receiving touch sensed signals via a plurality of conductive meshes disposed above the plurality of RX electrode lines in the touch sensing mode.

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